

Necessity of ‘two time zones: IST-I (UTC + 5 : 30 h) and IST-II (UTC + 6 : 30 h)’ in India and its implementation

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A strong demand of a separate time zone by northeast populace has been a matter of great debate for a very long period. However, no implementable solution to this genuine problem has yet been proposed. The CSIR-National Physical Laboratory, CSIR-NPL (the National Measurement Institute, NMI, of India and custodian of Indian Standard Time, IST) proposes an implementable solution that puts the country in two time zones: (i) IST-I (UTC + 5 : 30 h, represented by longitude passing through 82°33'E) covering the regions falling between longitude 68°7'E and 89°52'E and (ii) IST-II (UTC + 6 : 30 h, represented by longitude passing through 97°30'E) encompassing the regions between 89°52'E and 97°25'E. The proposed demarcation line between IST-I and IST-II, falling at longitude 89°52'E, is derived from analyses of synchronizing the circadian clocks to normal office hours (9 : 00 a.m. to 5 : 30 p.m.). This demarcation line passes through the border of West Bengal and Assam and has a narrow spatial extension, which makes it easier to implement from the railways point of view. Once approved, the implementation would require establishment of a laboratory for ‘Primary Time Ensemble – II’ generating IST-II in any of the north-eastern states, which would be equivalent to the existing ‘Primary Time Ensemble-I’ at CSIR-NPL, New Delhi.

Keywords: Circadian clock, energy saving, Indian standard time, longitude, Sun graphs, two time zone.

THE people, legislators and industrialists from northeast part of the country have been demanding a separate time zone for a long time as they genuinely face problems with the existing Indian Standard Time (IST)¹. The existing IST is said to be badly affecting their lives as the Sun rises and sets much earlier than the official working hours. Early sunrise leads to loss of many daylight hours by the time offices or educational institutions open. In winter, this problem gets even more severe as the Sun sets much early and therefore, more consumption of electricity is required to keep life active. Very recently, the Gauhati High Court also dismissed a public interest litigation seeking a separate time zone for northeast¹.

Earth spins (15° every hour) about its axis completing a rotation in every 24 h. Thus Earth is divided into 24 sections or time zones – each time zone being 15° of longitude wide, as shown in Figure 1 (ref. 2). The imaginary

dividing longitude lines begin at Greenwich (a suburb of London), which is now defined as the universal coordinated time (UTC = 0 : 00 h). UTC is provided by International Bureau of Weights and Measurers (BIPM) located in Sevres, France³. BIPM has a practical scale of time, known as International Atomic Time (TAI), for a continuous temporal reference of time. TAI is calculated using data from more than 400 atomic clocks in over fifty national laboratories and has the scale unit of SI second defined as the duration for 9,192,631,770 oscillations between two hyperfine ground states of Caesium atoms⁴. TAI is a uniform and very stable scale but does not keep in step with the slightly irregular rotation of the Earth. Therefore, for public and practical purposes UTC is used, which is identical with TAI, except that from time to time a leap second is added to ensure that, when averaged over a year, the Sun crosses the Greenwich meridian at noon UTC to within 0.9 sec. The dates of application of the leap second are decided by the International Earth Rotation Service (IERS)⁵.

It is evident from Figure 1 that as one moves west from UTC (0.00 h) line, every 15-degree time zone is an hour earlier than UTC, while each time zone to the east is an hour later. Having different time zones implies that no

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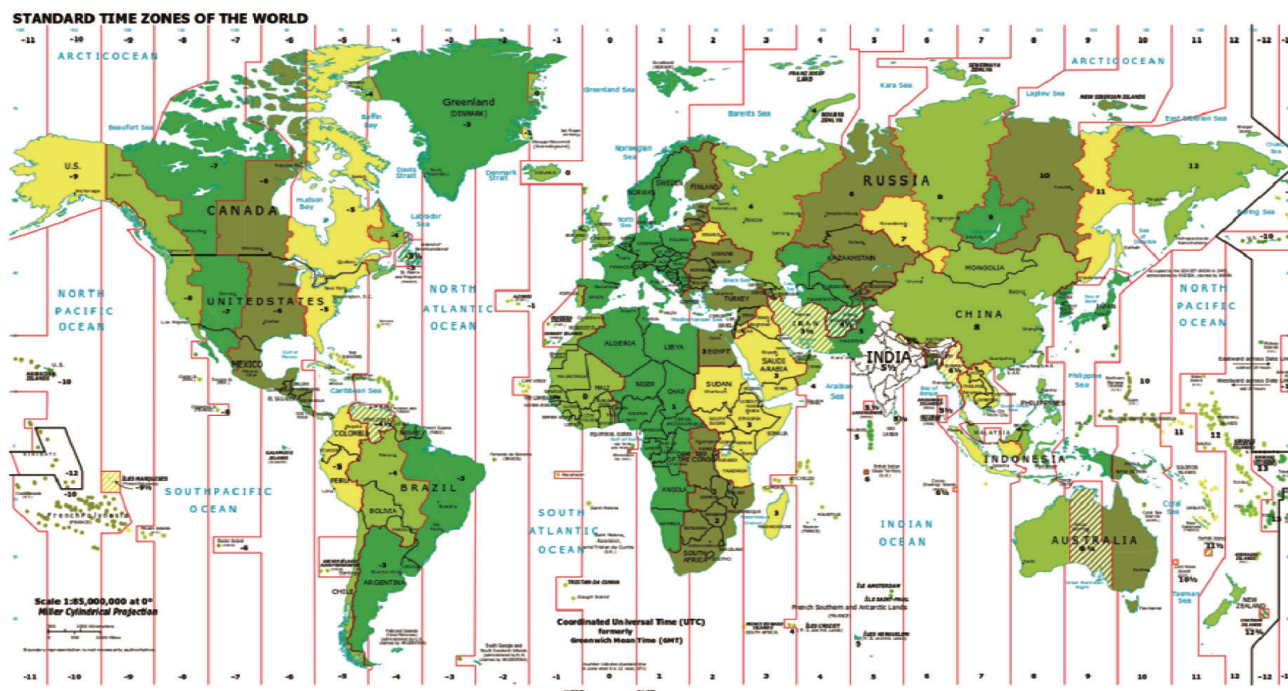


Figure 1. World time zone map depicting the UTC (0:00 h) and successive longitudes at every 15° separation corresponding to an hour. Also shown are the time zones adopted by different countries. Adapted from [https://commons.wikimedia.org/wiki/File:Standard_time_zones_of_the_world_\(2012\).svg](https://commons.wikimedia.org/wiki/File:Standard_time_zones_of_the_world_(2012).svg)

matter where one lives on the Earth, the noon is the middle of the day when the Sun is highest, while midnight is the middle of the night. The boundaries of many countries extend over several time-zones, and therefore, to keep one time zone across the country or introduce multiple time zones is the responsibility of the respective governments. Many countries have legal time, which essentially is the official time of a country, including current date, hour, minute and second. Legal time is usually defined by the law with appropriate assignment for time keeping and its dissemination in the country. Worldwide, the National Meteorology Institutes (NMI) – who are signatories of ‘Metre Convention’⁶ and have all required knowledge and technical competence – perform the task of time-keeping and its dissemination. NMIs send their clock data to BIPM and BIPM calculates the actual international time scale (TAI) based on this data. For example, in the United States, time by law is divided into nine standard time zones along with daylight saving time (DST)⁷. In US, the official time keeping services are provided through highly accurate and precise atomic clocks by the National Institute of Standards and Technology (NIST) and the United States Naval Observatory (USNO)^{8,9}. The atomic clocks of NIST and USNO are kept synchronized with each other and are traceable to UTC provided by BIPM, France.

In India, the CSIR-National Physical Laboratory (CSIR-NPL) is the NMI of the country and is responsible for generation and dissemination of the IST¹⁰. Currently, India observes a single time zone based on the longitude

passing through 82°33'E. The official IST (UTC + 5:30 h) is generated and maintained by CSIR-NPL using ‘Primary Time Ensemble’ (consisting of 5 Caesium clocks and hydrogen maser), which is traceable to the UTC at BIPM. The IST generated by CSIR-NPL has an accuracy of 20 nano-seconds and is being used by various users including Indian Space Research Organisation (ISRO)¹¹. It may be noted that India extends from 68°7'E to 97°25'E with a spread of ~29°, which is equivalent to two time zones. The inconvenience caused by single time zone is faced by the people of the North-eastern states as mentioned earlier. In fact, in the past, several proposals for two time zones were recommended, but none of them was approved as they were found impractical for implementation. In particular, it was anticipated that two time zones would create chaos at the border as resetting of the clocks would be required with each crossing, and non-following can lead to confusion that can be dangerous, e.g. in case of railways where probability of accidents may increase. Another proposal to solve the concerns of northeast people was to advance the IST by half an hour, which would also save energy for the country¹².

In this article, we relook into the possibility of introducing the two time zones in India which is feasible and implementable. The proposed recommendations of two time zones are based on: (i) importance of sunrise and sunset timings on the biological activities of living beings; (ii) simple analyses of synchronizing the sunrise and sunset timings across the country to the usual office

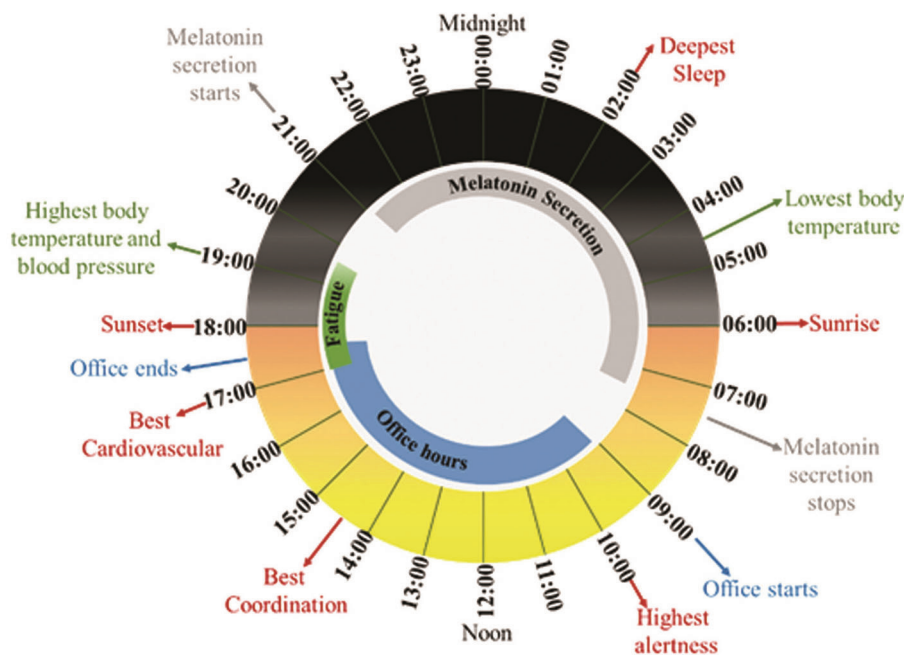


Figure 2. Biological clock affects the daily rhythm of many physiological processes. This diagram depicts the circadian patterns typical of someone who rises early in morning, eats lunch around noon, and sleeps at night (10 p.m.). The typical official working hours (9 a.m. to 5.30 p.m.) enhances his working efficiency. Although circadian rhythms tend to be synchronized with cycles of light and dark, other factors – such as ambient temperature, meal times, stress and exercise – can influence the timing as well. Adapted from https://commons.wikimedia.org/wiki/File%3ABiological_clock_human.svg.

hours of 9:00 a.m. to 5:30 p.m. (iii) minimization of the spatial extension at the proposed border of time demarcation so as to avoid any kind of railway accidents; (iv) if the proposed time-zones would be beneficial for the electricity saving, and (v) the technical implementation mechanisms of the proposed two new time-zones in the country.

Circadian rhythm and physiological processes

The 2017 Nobel Prize in physiology or medicine was awarded to Jeffrey C. Hall, Michael Rosbash and Michael W. Young for elucidating that plants, animals, and humans adapt their biological rhythm so that it is synchronized with the Earth's revolutions¹³. They established that biological species are ruled by internal clocks (biological clocks) that run on a 24 h light–dark cycle in synchronization with the Sun. They isolated a gene that controls the normal daily biological rhythm and have shown that this gene encodes a protein which accumulates in the cell during the night and degrades during the day. As a result, the metabolic, hormonal, central nervous system and neurotransmitter operates in rhythm with each other. Due to this synchronization, for example, humans fall asleep at night and plants synthesize chlorophyll in the presence of sunlight. Biological clock is so active that when we move from one time zone to another, it forces

us to sleep at an unusual time. This is commonly known as jetlag and it requires few days to resynchronize our biological clock with the local solar timings. With exquisite precision, the biological clocks adapt the physiology to the dramatically different phases of the day.

Figure 2 illustrates some of the biological activities and daily routines relative to the light and dark solar cycles¹⁴. The hormone 'melatonin' secreted from pineal glands located in the brain controls the sleep–wake cycle relative to the light–dark cycle. As shown in Figure 2, the melatonin secretion starts approximately 3 h after sunset and secretes for about 10 h following a particular distribution pattern. This maximizes during the midway of the secretion resulting in the deepest sleep (around 2 a.m.). The highest alertness is achieved about 4 h after sunrise, and the best coordination is achieved at 3 p.m. After the sunset, fatigue starts creeping in due to increased blood pressure and body temperature. Therefore, in order to make people work efficiently and be productive, it is necessary that the working hours should be synchronous to the biological clock as shown in Figure 2. In this case the working hours of 9 a.m.–5.30 p.m. suits the circadian rhythm. This is why, most of the advanced countries like US, follow multiple time zones. This allows synchronized circadian rhythm with light–dark cycle and provides necessary comfort to its citizen and maximizes their working efficiency. If the circadian rhythm is not synchronous to light–dark (sunrise/sunset)

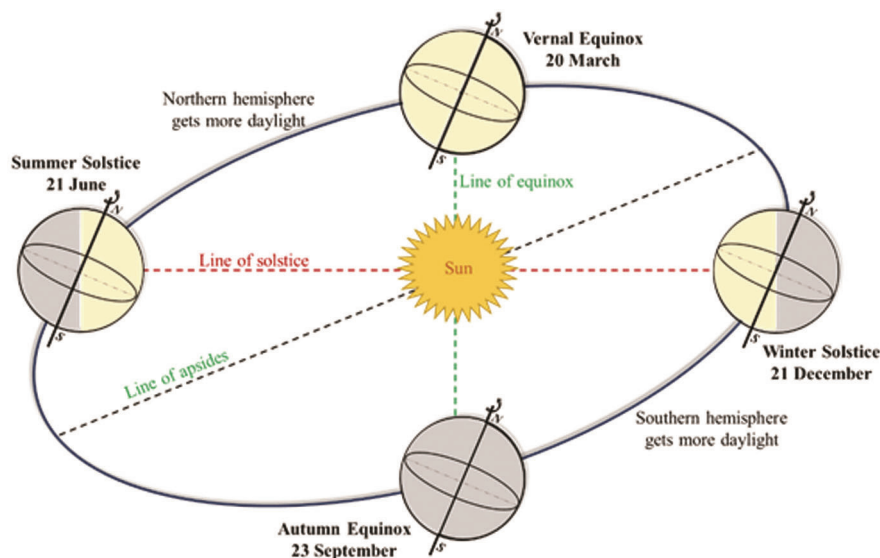


Figure 3. Rotation of Earth about its own axis and its revolution around the Sun resulting into light–dark cycles in a solar day and seasons respectively¹⁵. Adapted from https://en.wikipedia.org/wiki/Earth%27s_orbit#/media/File:Seasons1.svg.

cycle, the working efficiency of the people will be compromised. For example, if the Sun rises much earlier than the office hours, the phase of highest alertness gets wasted, and the best coordination time would overlap with lunch timings. In addition, a major part of late office hours cannot be efficiently utilized due to fatigue. Similarly, for late sunrise, people are not fully awake during office hours since melatonin secretion has not stopped yet. Keeping these concerns in mind, it is evident that human circadian rhythm is intimately tied to health, well-being and efficiency at work, which in turn, is intimately related to the overall socio-economic development of the region. It is therefore essential that the local time zone is set in such a way that regular day-to-day activities of the populace become synchronous to the light–dark cycles of the solar day.

Two time zones a necessity in India

As discussed in the previous section, it is seen that for the well-being and efficiency of the populace, the working hours should be within the appropriate slots of the circadian clock. From the perspective of India, in order to estimate how many time-zones the country should have, a critical analysis of the sunrise and sunset timings across the country over the year is required.

It is well known that the eccentricity of the Earth's orbit and its 23.4° tilted rotational axis, as shown in Figure 3, result in varying lengths of day and night over different seasons¹⁵. As Earth revolves around its elliptical orbit, tilt of the north pole with respect to Sun's position gradually changes from being farthest to closest. During

December to February, the north pole is tilted away from the Sun; thus the northern hemisphere receives less solar energy and experiences winter, while the southern hemisphere being tilted more towards the Sun experiences summer. On 21 December, the tilt of the north pole is farthest away from the Sun and so length of the day is the shortest, and this day is known as winter solstice. The exactly opposite scenario takes place from June to August when tilt of the north pole progressively comes closer to the Sun with the closest being just six months from winter solstice, i.e. on 21 June (known as summer solstice). On summer solstice, the entire northern hemisphere experiences the longest day of the year. On the other hand, the southerners being tilted away from Sun, during this duration face winter. Amidst solstices comes equinox, the condition when the Northern Pole is tilted neither too away nor too close to the Sun, thus bringing forth the spring season during March–May and autumn in September–November in the Northern Hemisphere. On 20 March and 23 September, exactly equal, i.e. 12 h of days and nights occur and are called as vernal equinox and autumn equinox respectively. India lies in the Northern Hemisphere and hence experiences summer in June and winter in December.

In order to map the sunrise and sunset timings across the country over the year using existing IST (UTC + 5.30 h), we have judiciously identified 10 locations for the analyses. These include Dong, Port Blair, Alipurduar, Gangtok, Kolkata, Mirzapur, Kanyakumari, Gilgitum, Kavaratti and GhuarMota. Due to the phenomenon explained in Figure 3, over the Indian sky, the relative direction of movement of Sun depends upon the season, i.e. in winter – from south-east to north-west, in

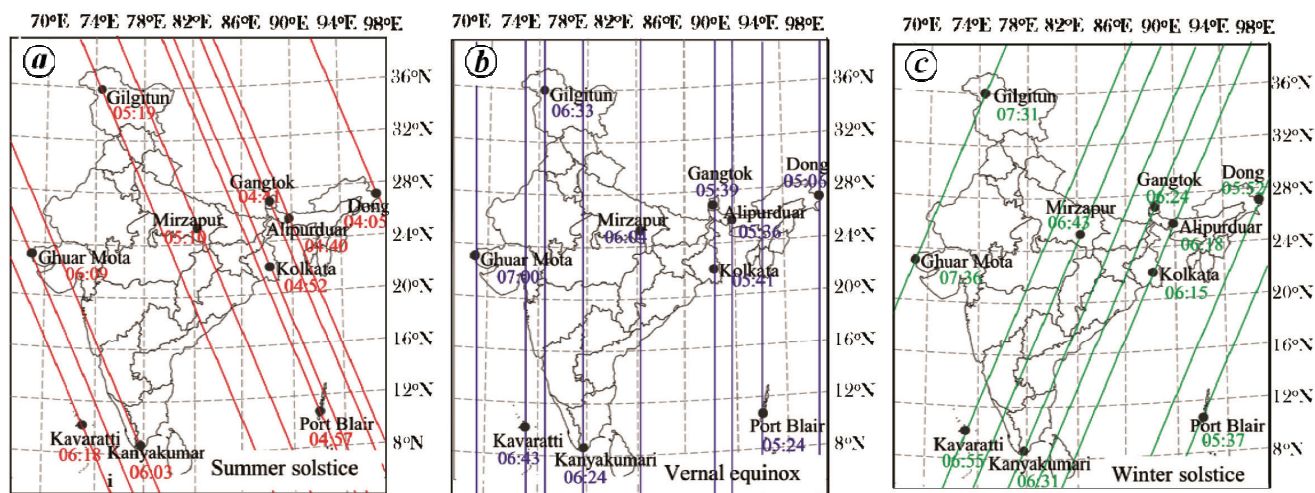


Figure 4. Lines of sunrise estimated from the yearly Sun graphs (<https://www.timeanddate.com/sun>)¹⁶ through selected 10 places in India based on the existing IST (UTC + 5.30 h) during (a) summer solstice, (b) vernal equinox and (c) winter solstice.

spring – from east to west, in summer – from north-east to south-west, and in autumn – from east to west. As a result, the line of sunrise – an imaginary line connecting different places where Sun rises at the same time changes everyday over the year. The lines of sunrise passing through the 10 selected cities, estimated from the yearly Sun graphs (source: <https://www.timeanddate.com/sun>)¹⁶, during summer solstice, spring equinox and winter solstice are shown in Figure 4. It is evident that in India, the lines of sunrise closely follow the longitudes only during spring equinox and autumn equinox, implying that the Sun rises earlier in a place which is relatively in the east. For example, the Sun rises earlier in Dong (5.06 a.m.), which is in east compared to Port Blair (5.24 a.m.). Similar is the case with Kavaratti (6.43 a.m.) and GuharMota (7 a.m.). Also, the time difference between the extreme east (Dong) and extreme west (GhuarMota) is close to 2 h. However, during winter and summer, the lines of sunrise do not follow the longitudes. This leads to different sunrise patterns, as shown in Figure 4 a and c. For example, in summer the Sun rises earlier in GhuarMota (6.09 a.m.) despite being in the west compared to Kavaratti (6.18 a.m.). Similarly, in winter the Sun rises later in Dong (5.52 a.m.), which is in the east compared to Port Blair (5.37 a.m.). As the circadian rhythm is based on day/night circle, therefore, any decision to select a specific time-zone should also include seasonal variation of sunrise and sunset timings.

In Figure 5, we draw the sunrise and sunset times based on existing IST (UTC + 5.30 h) along with duration of the day in the selected 10 places during three seasons. The data were estimated from the yearly sun-graphs¹⁶. The dotted lines in the figure at 9.00 a.m. and 5.30 p.m. correspond to office opening and closing timings. Based on the availability of sunlight during office hours, the

selected 10 locations can be classified into the following three categories: (i) available for all the four seasons of a year (Kanyakumari, Kavaratti and GuharMota) and the daylight distribution is quite symmetric with respect to the office timings; (ii) available for three seasons except winter (Alipurduar, Kolkata, Gangtok, Mirzapur and Gilgitum) and the daylight distribution is slightly asymmetric with respect to the office timings; and (iii) available for only one season, i.e. summer (Dong and Port Blair). As seen in Figure 5, the daylight distribution is asymmetric compared to the office timings, and is shifted towards early morning.

Therefore, from the circadian rhythm point of view, the existing IST (UTC + 5.30 h) is highly suitable for Kanyakumari, Kavaratti, and Guhar Mota, manageable for Alipurduar, Kolkata, Gangtok, Mirzapur and Gilgitum, but highly unsuitable for Dong and Port Blair. Therefore, the local time needs to be changed in the regions of Dong and Port Blair and this has exactly been the demand from the people of this region. If one additional hour is added to the IST for this region, which then becomes IST-II (UTC + 6.30 h). The corresponding sunrise and sunset timings with respect to office hours are shown in Figure 6. It is evident that making IST-II (UTC + 6.30 h) allows maximum utilization of daylight. Therefore, additional time zone IST-II (UTC + 6.30 h) is a necessity for the extreme north-east regions, covering the states Assam, Meghalaya, Nagaland, Arunachal Pradesh, Manipur, Mizoram and Tripura, and Andaman and Nicobar Islands. It may be noted that the ‘chaibagaan’ time’ – clocks set one hour ahead of IST and equal to the proposed IST-II – is already being followed unofficially in Assam since British period. However, the existing IST, hereafter renamed as IST-I (UTC + 5.30 h) is suitable for the rest of India.

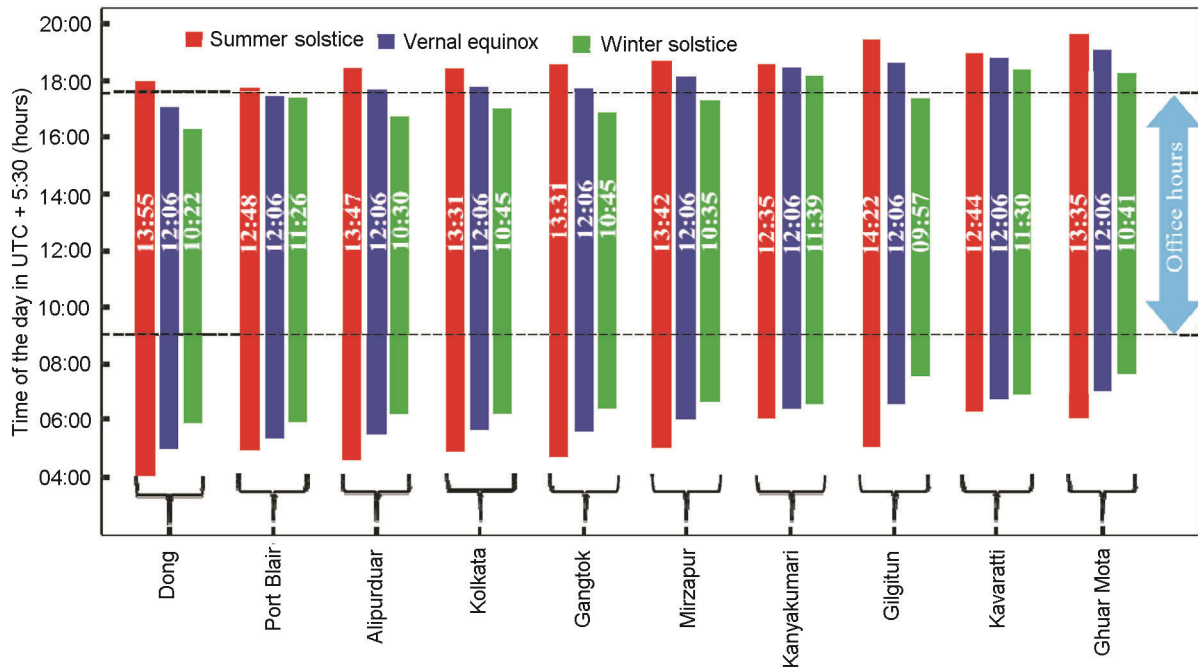


Figure 5. Sunrise and sunset timings based on existing IST (UTC + 5.30 h) and corresponding daylight hours estimated from the sun-graph (source: <https://www.timeanddate.com/sun>)¹⁶ during summer solstice (red), vernal equinox (blue) and winter equinox (green). The dotted lines represent typical office hours (9 : 00 a.m. – 5 : 30 p.m. IST) in India.

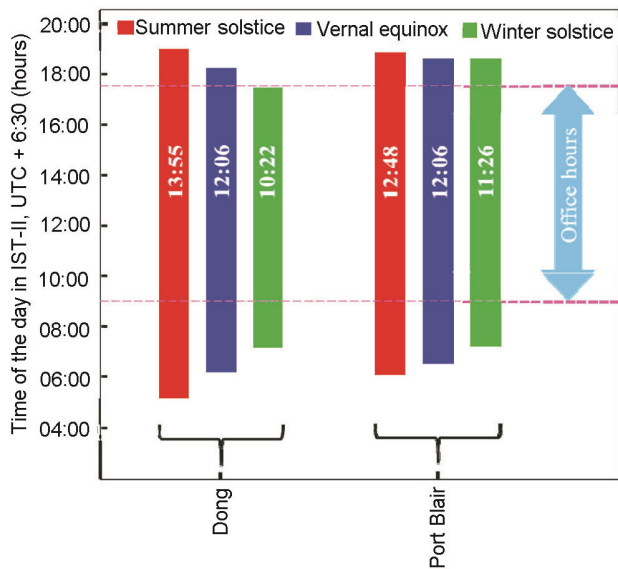


Figure 6. Office hours falling within the daylight hours in Dong and Port Blair if new time-zone IST-II (UTC + 6 : 30 h) gets implemented.

The border between IST-I and IST-II

As discussed above, two time-zones namely IST-I (UTC + 5.30 h) and IST-II (UTC + 6.30 h) are a necessity of India, and now the question is how to choose the border between these two time zones. As the railway signals have not yet been fully automated in the country, the border between the two time zones should have a very

narrow spatial-width with minimum number of train stations so that the train timings while crossing the border can be managed manually without any untoward incidents. Fortunately, for India, the border between West Bengal and Assam provides this opportunity, as shown in Figure 7, as only two railway stations namely New Cooch Behar and Alipurduar need to be managed for time adjustment. In addition, as discussed earlier, IST-I (UTC + 5.30 h) suits well for the Alipurduar. Therefore, the proposed demarcation line passes through the border of West Bengal and Assam that has a narrow spatial extension and passes through longitude 89°52'E. Thus, the proposed two time zones for India are: (i) IST-I (UTC + 5 : 30 h, represented by longitude passing through 82°33'E) and covers the regions falling between longitudes 68°7'E and 89°52'E and (ii) IST-II (UTC + 6:30 h, represented by longitude passing through 97°30'E) and covers the regions between 89°52'E and 97°25'E, which includes Assam, Meghalaya, Nagaland, Arunachal Pradesh, Manipur, Mizoram, Tripura and, Andaman and Nicobar Islands.

Advantage of IST-II in terms of electricity saving

The main advantage of IST-II is making the circadian rhythm synchronous to the solar day, which would enhance the efficiency of people working in the region, and hence, the overall productivity. In addition, due to better utilization of daylight, one can expect that a

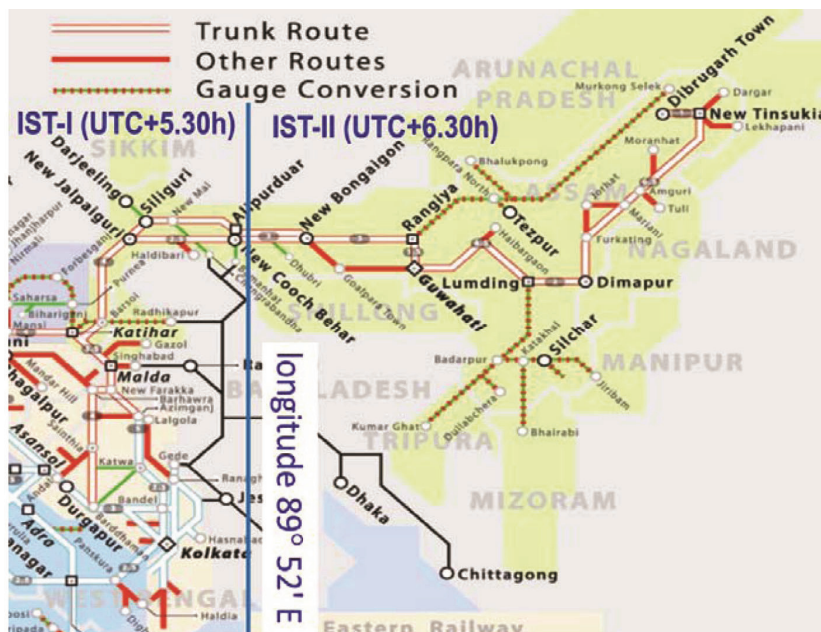


Figure 7. The Indian eastern railway network connecting West Bengal and north-eastern states. The proposed line of demarcation of IST-I and IST-II passing through long. 89°52'E is the border of West Bengal and Assam and has a narrow spatial extension and having only two railway stations, New Cooch Behar and Alipurduar. Adapted from: https://en.wikipedia.org/wiki/Northeast_Frontier_Railway#/media/File:Northeast_India_railway.png¹⁹.

good amount of electricity will also be saved in this region with introduction of IST-II. To estimate the possible energy savings, we have adopted a direct method that uses state-wise population, per capita electricity consumption and the available daylight hours extracted from the Sun graphs. The analysis is made based on authentic data available for the year 2011. Table 1 lists state-wise population (P_s) from 2011 census, per capita electricity consumption (w_s) and per capita per hour electricity consumption in the commercial sectors (w_{cs})¹⁷, where s and cs stand for state and commercial sectors respectively. Efficient usage of daylight hours will mostly result in energy savings from the commercial sectors (this includes non-manufacturing establishments such as multi-family residences, educational institutions, office buildings, hotels and restaurants, medical establishments, etc.), which consumed 8.33% of the total electricity as on 2011 (ref. 18). The daylight hours on a specific date are extracted from the location-specific Sun graphs¹⁶. We have analysed the Sun graphs corresponding to summer solstice, vernal equinox, winter solstice and autumn equinox as shown in Figure 8 for estimation of hours of energy saving by two time zones implementation. If each person is saving t_s hours of electricity daily, then total annual savings amounts to be

$$E = \sum_s (w_{cs} P_s t_s) / 24 \text{ kWh},$$

where the subscript s indicates a state. Using this equation, the energy savings resulting from implementing

the suggested two time zone are estimated for all the states falling under IST-II which are presented in Table 1. The estimated annual energy saving comes out to be 2×10^7 kWh, which is significant considering the fact that these states are already short on electric power.

Implementation of IST-I and IST-II

The implementation of two time zones IST-I and IST-II has technical as well as legislative requirements. As mentioned earlier, the existing official IST (UTC + 5.30 h) is maintained by CSIR-NPL using ‘Primary Time Ensemble’, which is traceable to the UTC at BIPM. In order to create two time zones in the country, the existing IST would become IST-I. For IST-II, CSIR-NPL would need to set up another laboratory consisting of ‘Primary Time Ensemble-II’ traceable to the UTC at BIPM, which would be identical to that of ‘Primary Time Ensemble-I’ located at CSIR-NPL. The location of this new laboratory could be at any place in the proposed IST-II time-zone. As the CSIR-NPL already has the technical expertise in the generation and dissemination of IST, duplicating this facility is just a matter of availability of appropriate funds and space. CSIR-NPL is a signatory of CIPM (Comité International des Poids et Mesures) Mutual Recognition Arrangement (CIPM-MRA), which would facilitate the synchronization of ‘Primary Time Ensemble-II’ to UTC at BIPM for the traceability. In addition, both the Primary Time Ensemble generating IST-I and IST-II would be interlinked via two way satellite time and

Table 1. Estimation of annual energy saving in the states proposed to follow IST-II (UTC + 6 : 30)

States proposed to follow IST-II (UTC + 6 : 30)	Population ¹⁷ P_s	Per capita electricity consumption, w_s ²⁰	Per capita electricity consumption in commercial sector, w_{cs} (= 8.33% of w_s kWh)	Annual energy savings $\times 10^7$ kWh
Andaman and Nicobar	3,79,944	501	41.73	2
Arunachal Pradesh	13,82,611	683	56.89	
Assam	3,11,69,272	250	20.83	
Manipur	27,21,756	236	19.66	
Meghalaya	29,64,007	658	54.81	
Mizoram	10,91,014	507	42.23	
Nagaland	19,80,602	257	21.41	
Tripura	36,71,032	254	21.16	

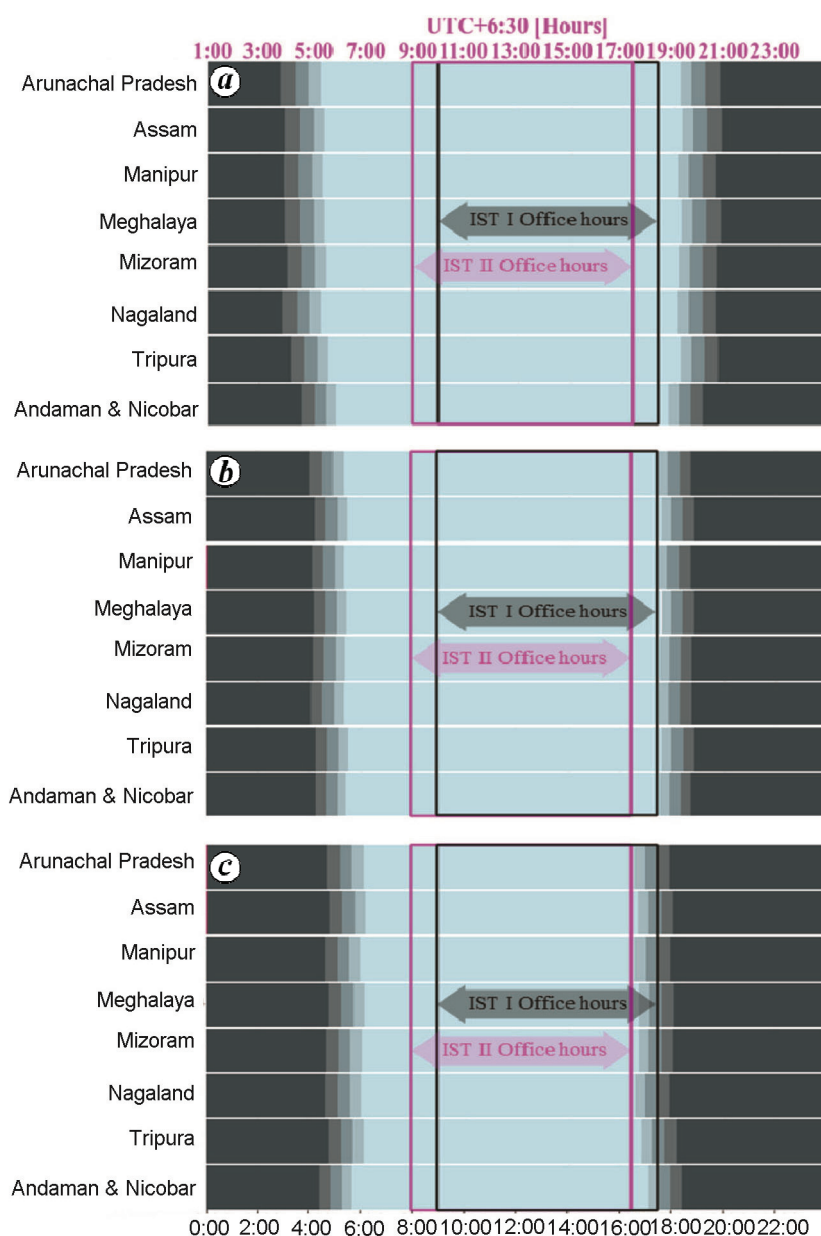


Figure 8. Typical sun-graphs showing the light–dark hours for all the states falling under the proposed IST-II time zone during (a) summer solstice, (b) equinox and (c) winter solstice. Bottom x-axis scale represents IST-I (UTC + 5.30 h) and top x-axis represents IST-II (UTC + 6.30 h). Significant enhancement of daylight hours is evident if IST-II is implemented.

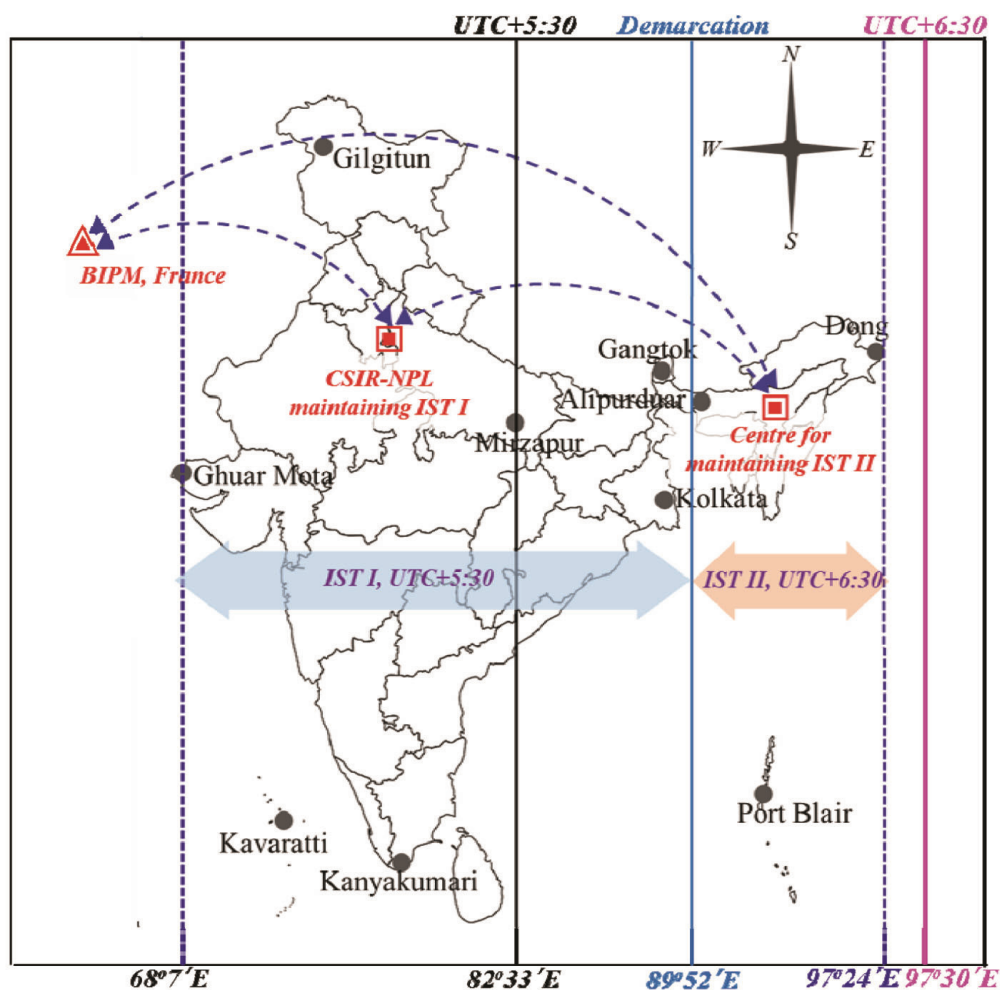


Figure 9. Proposed map of India showing two time zones: IST-I (UTC + 5 : 30 h) and IST-II (UTC + 6 : 30 h). A new centre for generating IST-II through ‘Primary Time Ensemble-I’ is proposed in the north-eastern state, which will be synchronized to the ‘Primary Time Ensemble-II’ generating IST-I at CSIR-NPL, New Delhi as well as to UTC at BIPM.

frequency transfer (TWSTFT) and common view global navigation satellite system (CVGNSS). The proposed map of India showing two time zones is shown in Figure 9.

Summary

In this article we have shown that the two time zones, namely IST-I (UTC + 5 : 30 h) and IST-II (UTC+6 : 30 h), indeed are a requirement of the country. The demarcation line between IST-I and IST-II passes through the border of West Bengal and Assam and falls at longitude 89° 52’ E. The states falling under IST-II would be Assam, Meghalaya, Nagaland, Arunachal Pradesh, Manipur, Mizoram, Tripura and, Andaman and Nicobar Islands. Implementation of IST-II in these states would not only enhance the efficiency of populace as their daily working hours get synchronous to the circadian clocks, but would also save significant amount of energy. The rest of India remains under IST-I. Technically, the two time zones in

the country can be easily implemented by CSIR-NPL as it has the desired mandate and the expertise.

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